

Portland Harbor Superfund Site

2018 Baseline Sampling
Surface Sediment Evaluation



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2018 Baseline Sampling



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2018 Baseline Sampling Study Design

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Unbiased Sampling Program

Baseline (SRS) Samples

- Unbiased Dataset
- Creation of 428 grid cells distributed throughout the Superfund Site
 - Randomly placed a surface sediment sampling location in each grid cell
- Intended for comparison against future sampling events

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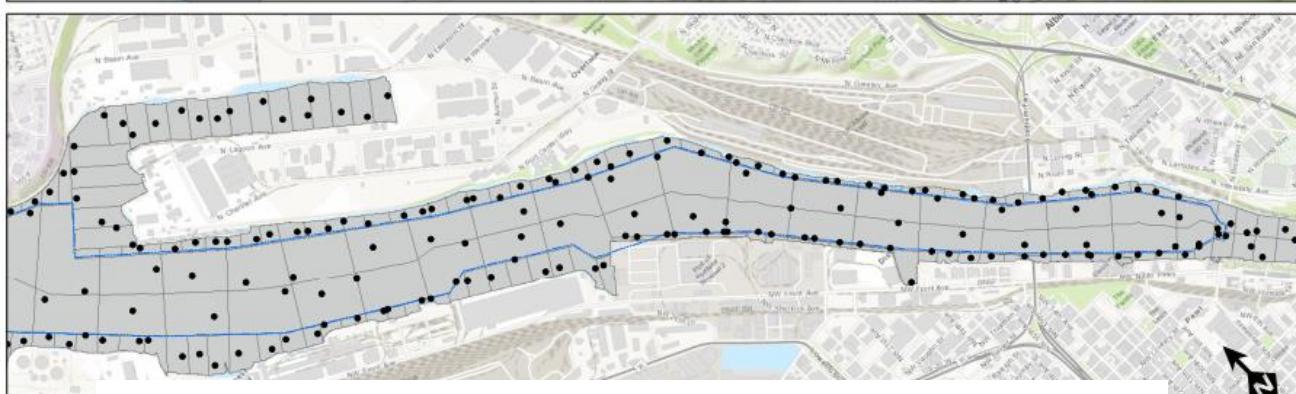
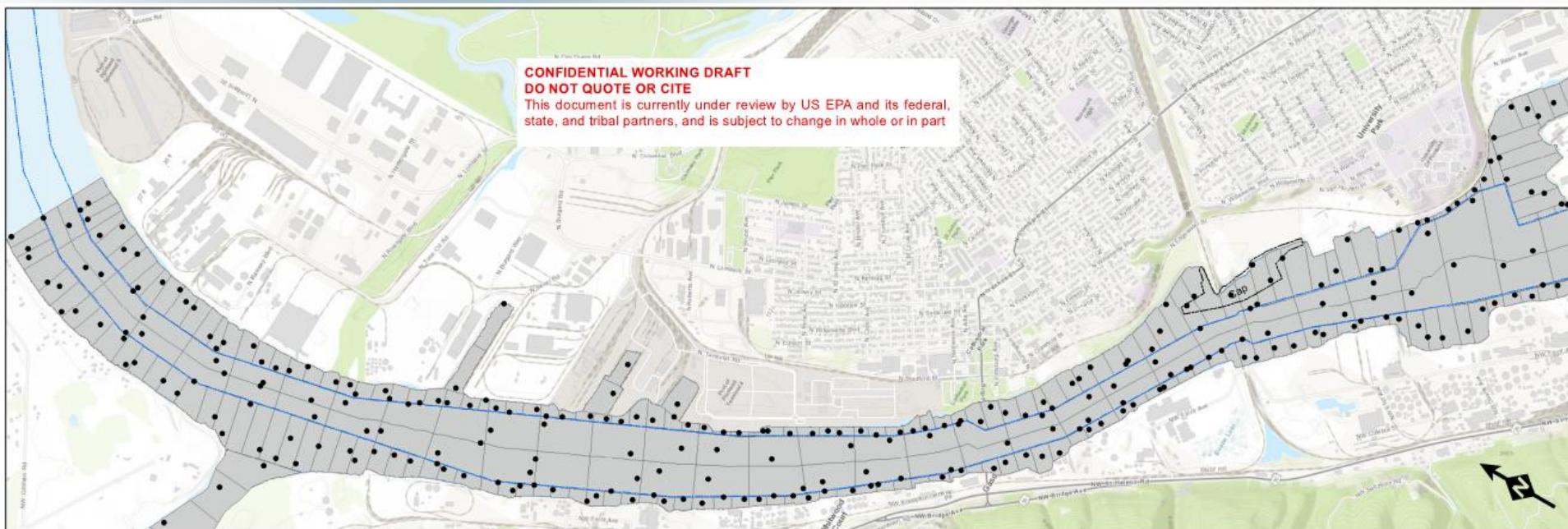
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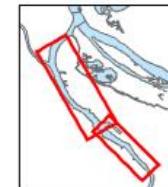


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Legend

- Baseline Sample Locations
- Baseline Sample Grid
- Navigation Channel

0 1,000 2,000 3,000 4,000
Feet



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Biased Sampling Program

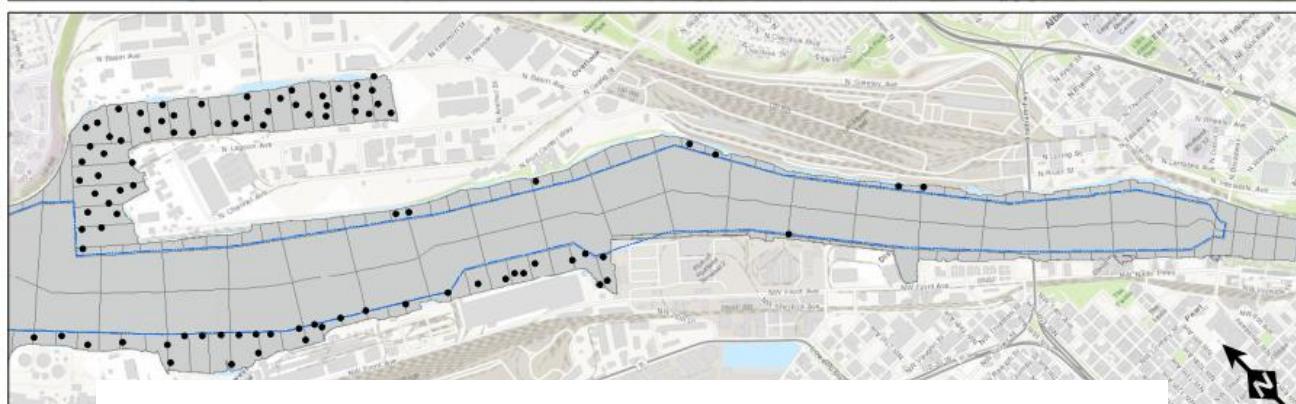
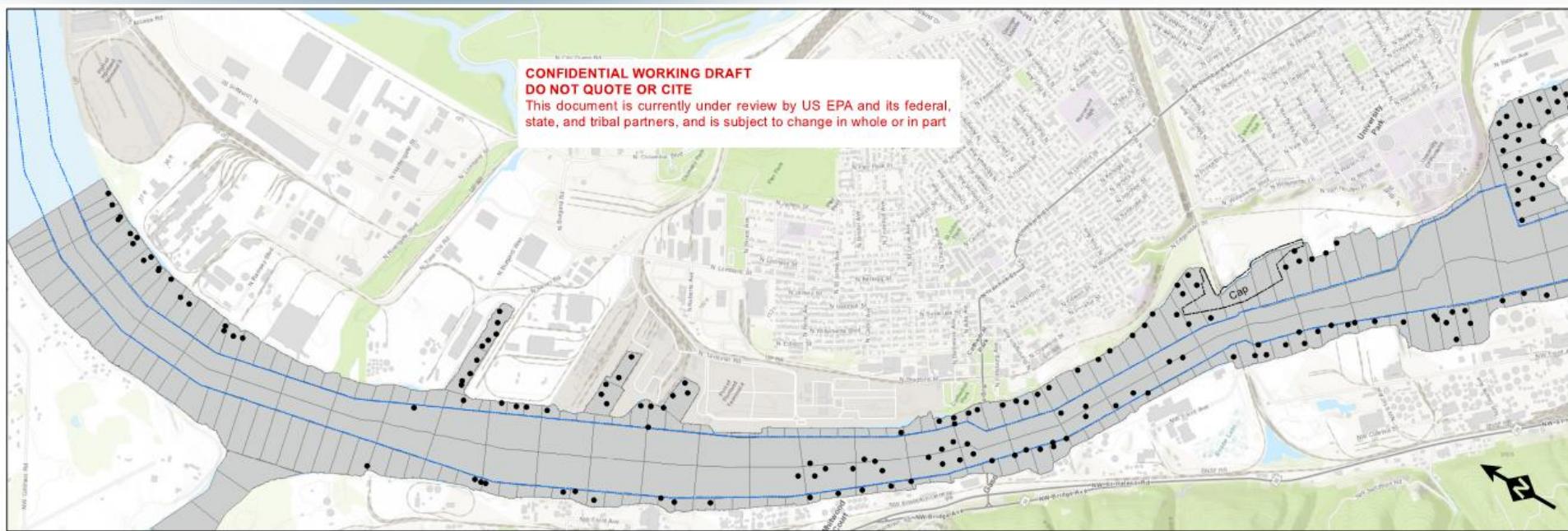
SMA Samples

- Biased sampling targeted ROD SMAs
- Intended to support SMA delineation and allocation
- Low spatial density likely not suitable for full delineation of SMAs

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Legend

- SMA Sample Locations
- Baseline Sample Grid
- Navigation Channel

0 1,000 2,000 3,000 4,000
Feet

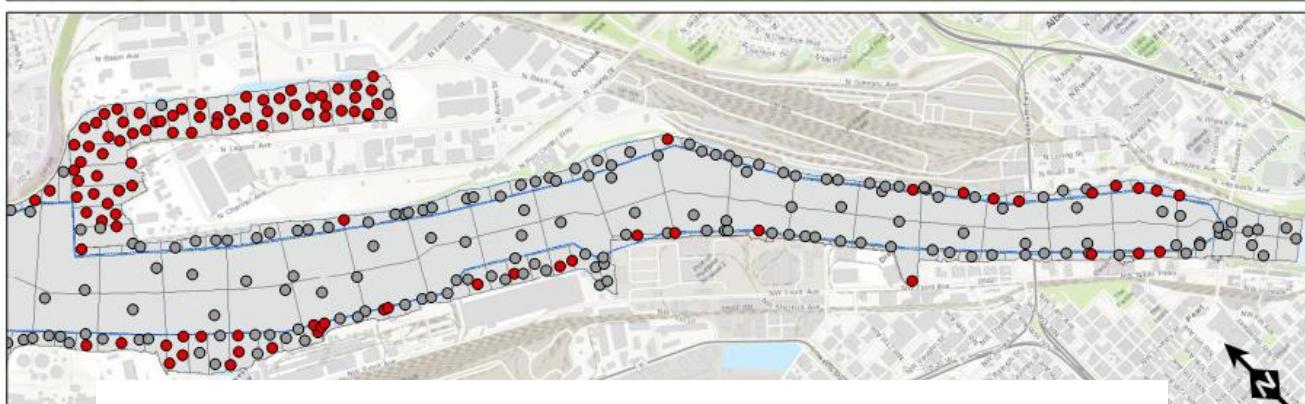
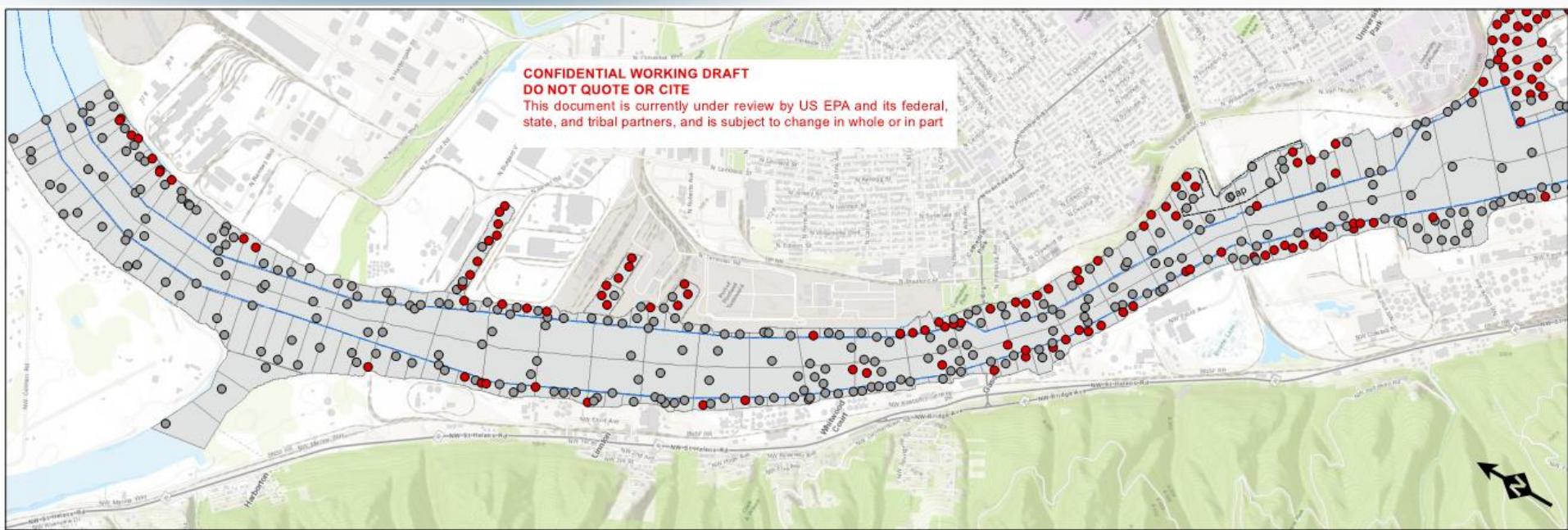


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Distribution of Surface Sediment SMA Sample Locations (2018)

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Legend

PDI Sample Locations

- Above RAL
 - Below RAL
- Baseline Sample Grid
- Navigation Channel

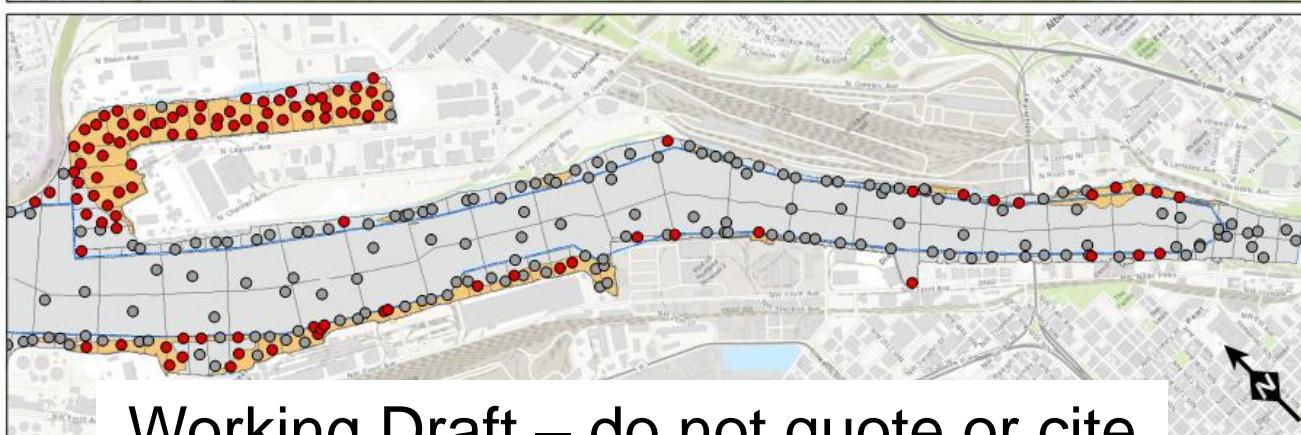
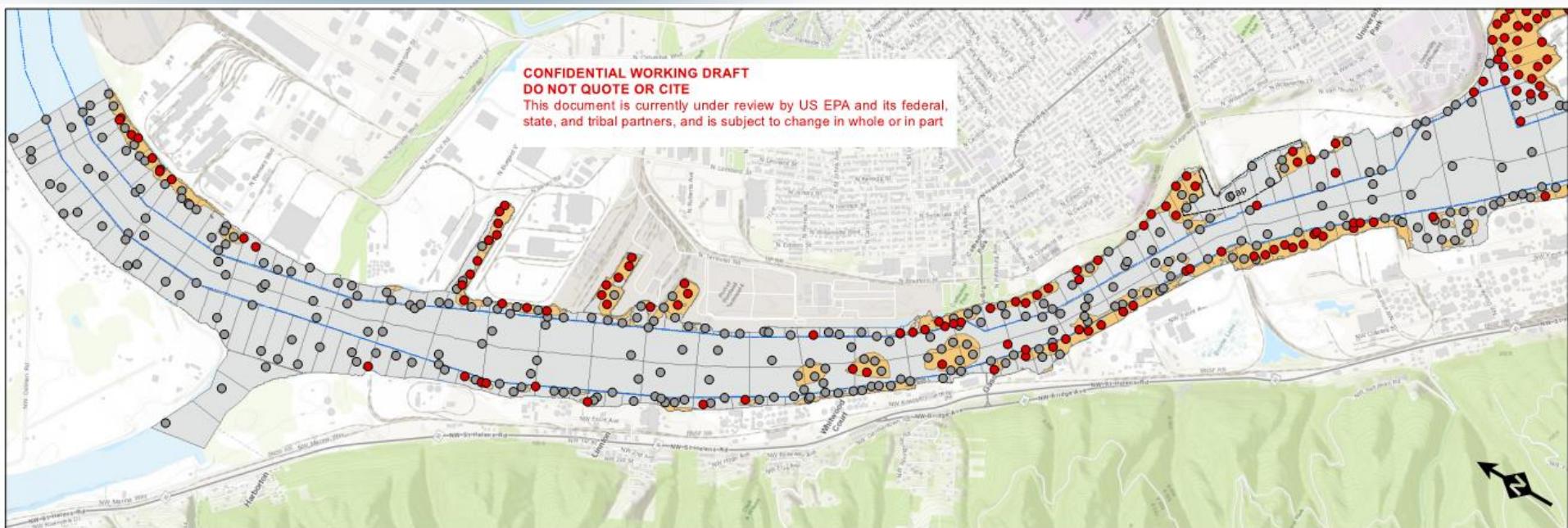
0 1,000 2,000 3,000 4,000
Feet



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Legend
PDI Sample Locations
● Above RAL
● Below RAL
● Baseline Sample Grid
● Remediation Area - Selected Remedy
● Navigation Channel

0 1,000 2,000 3,000 4,000
Feet



Interpolation-Based SMAs

- The ROD mapped SMAs using “interpolation” based on RI/FS data
- The 2018 surface sediment data **can** be used to interpolate SMAs
- However:
 - 2018 data are much more sparse in contaminated areas than RI/FS data
 - ★ 661 2018 samples vs 2,440 RI/FS samples
 - ★ Interpolation between sparse data can mischaracterize actual conditions
 - The efforts sampled different locations, limiting a true comparison
- SMAs to be refined in Remedial Design
 - Sampling at much higher spatial density
 - ROD requires 3-D SMA delineation (i.e., surface and subsurface sediment)

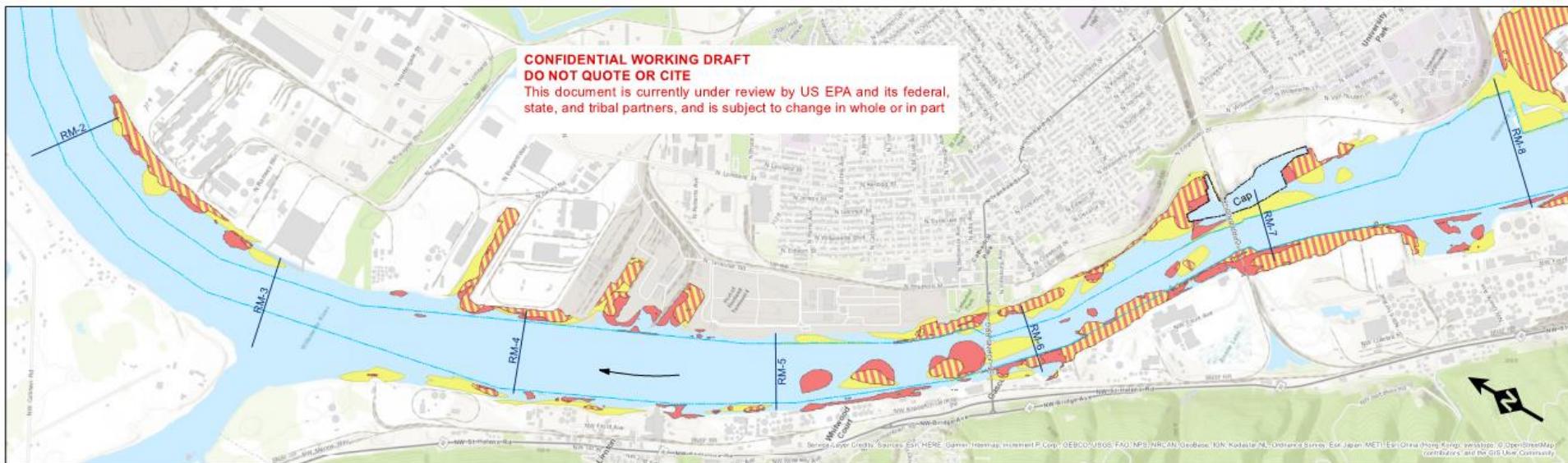
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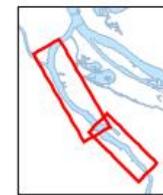


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- ← River Flow
- Navigation Channel
- Both ROD and PDI Data (~246 acres)
- PDI Data Only (~176 acres)
- ROD Only (~118 acres)

0 1,000 2,000 3,000 4,000
Feet



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Have the SMA footprints changed?

- Based on this approximation, about two-thirds of the interpolated areas are the same.
- Known areas of contamination with RAL exceedances haven't changed substantially
- Estimated SMA acreage increased from 365 acres to **422 acres**

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Interpolated Results are Highly Uncertain

Why?

- Interpolation methods are good for visualizations and estimates, but not precise comparisons.
- Why larger footprint?
 - Low spatial density of 2018 samples could explain larger footprint (interpolations across unsampled areas can bring in acres)
 - 2018 sampling included broader spatial coverage of dioxin/furan samples (sitewide vs localized sampling)
- 2018 footprints nor the ROD footprints will look exactly like the final remedy area
 - Needs to be determined with higher density sampling during Remedial Design

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SDU Change Analysis

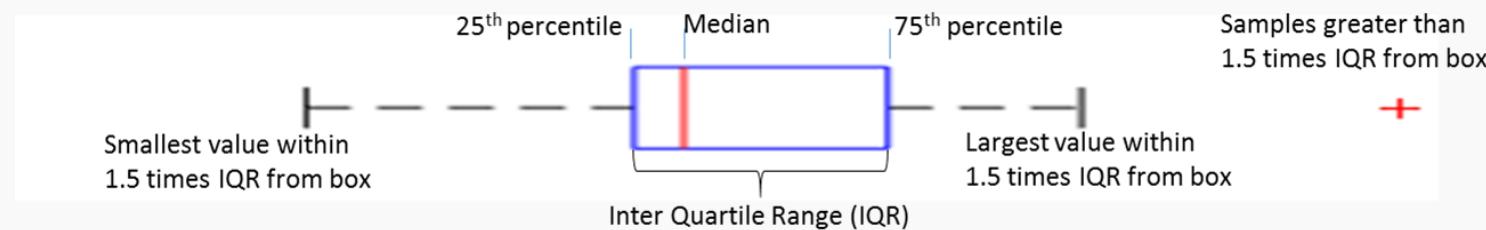
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2018 Baseline to RI/FS Concentration Ratio Analyses

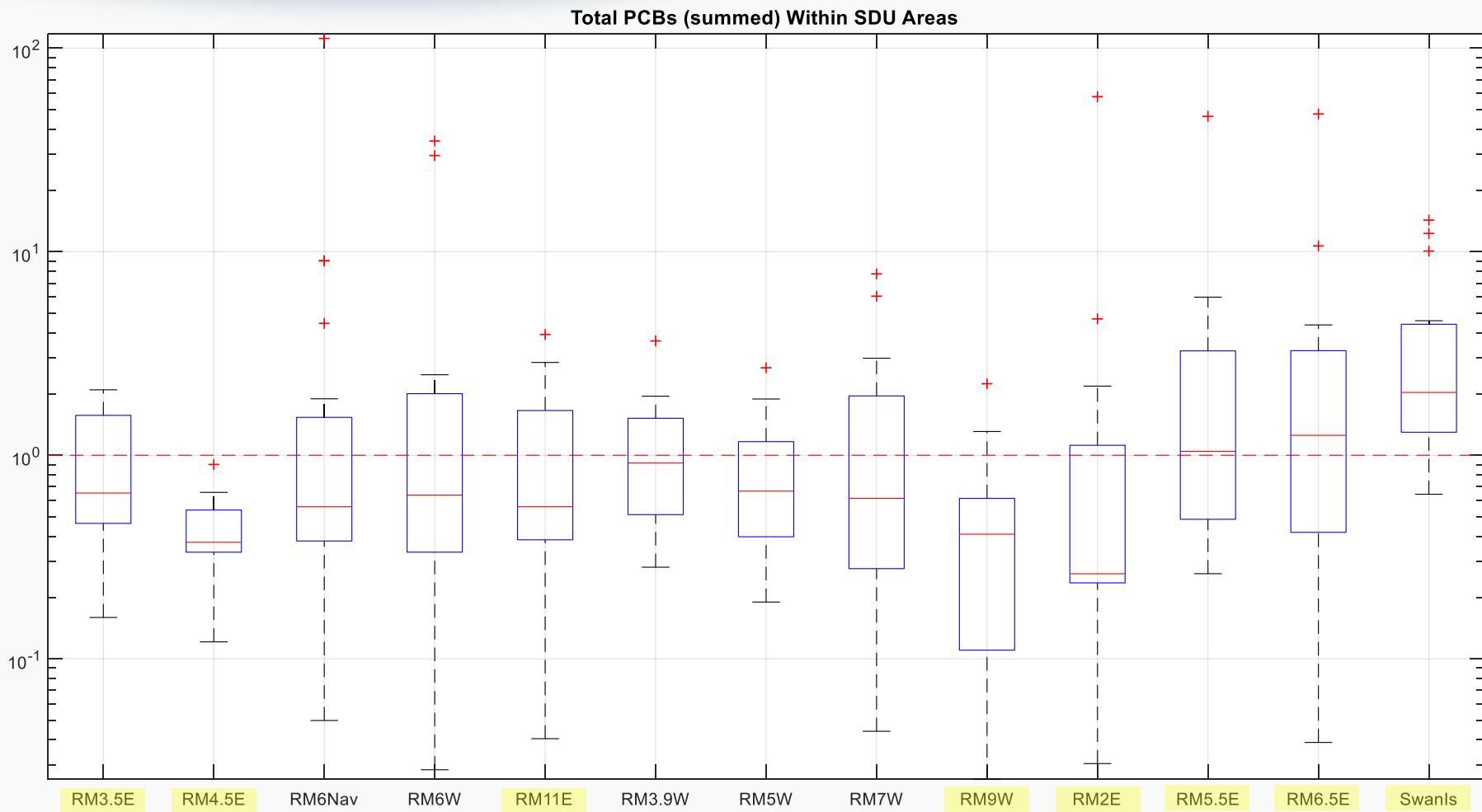


- Ratio of 2018 Baseline concentrations to median FS concentrations in corresponding baseline sampling grid cells
- Ratios less than 1 indicate declines in concentration
- Boxes that overlap the red dashed line at 1 indicate little change
- Yellow highlight indicates that a focused COC is a predominant contaminant in that SDU

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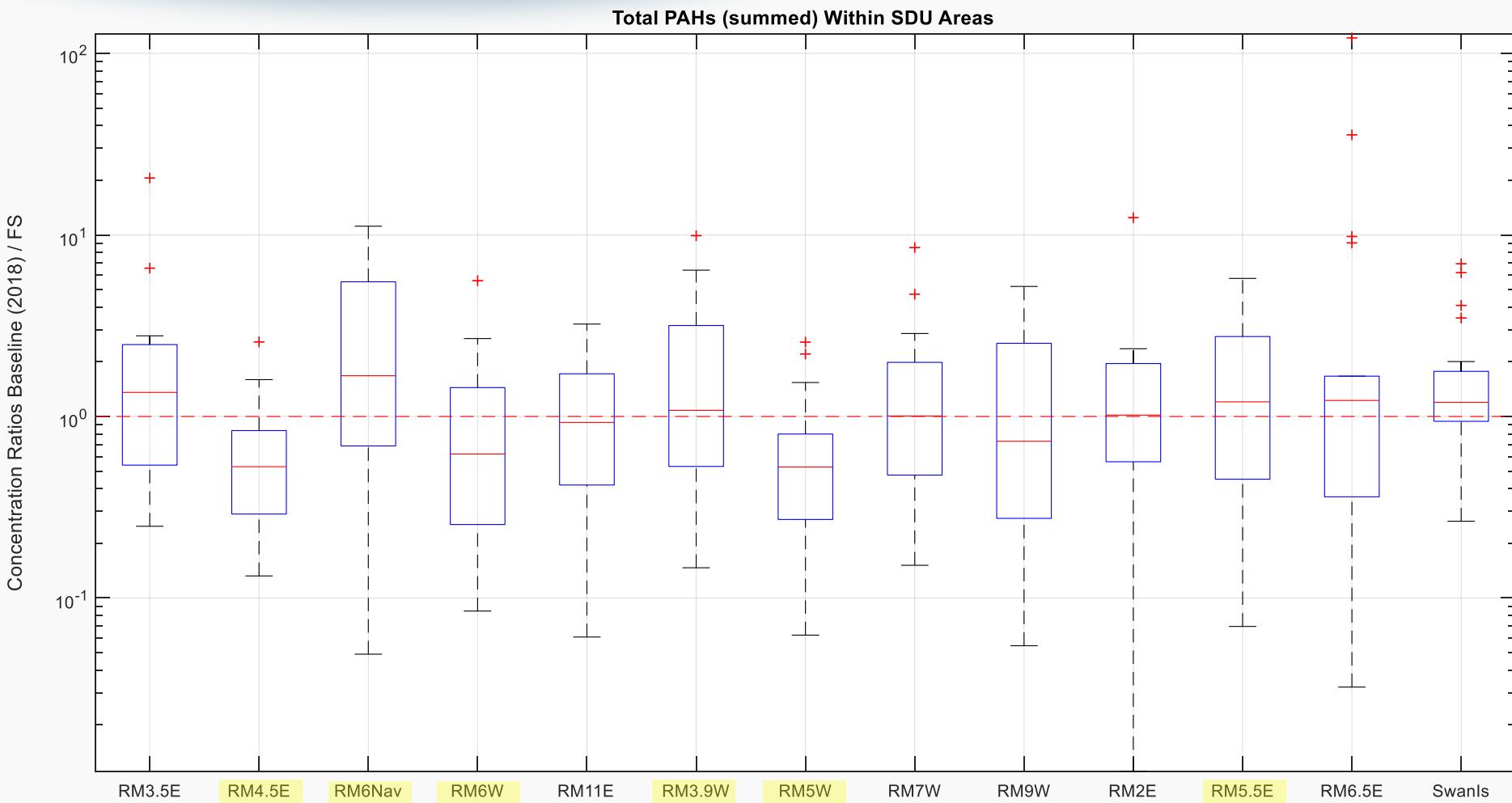
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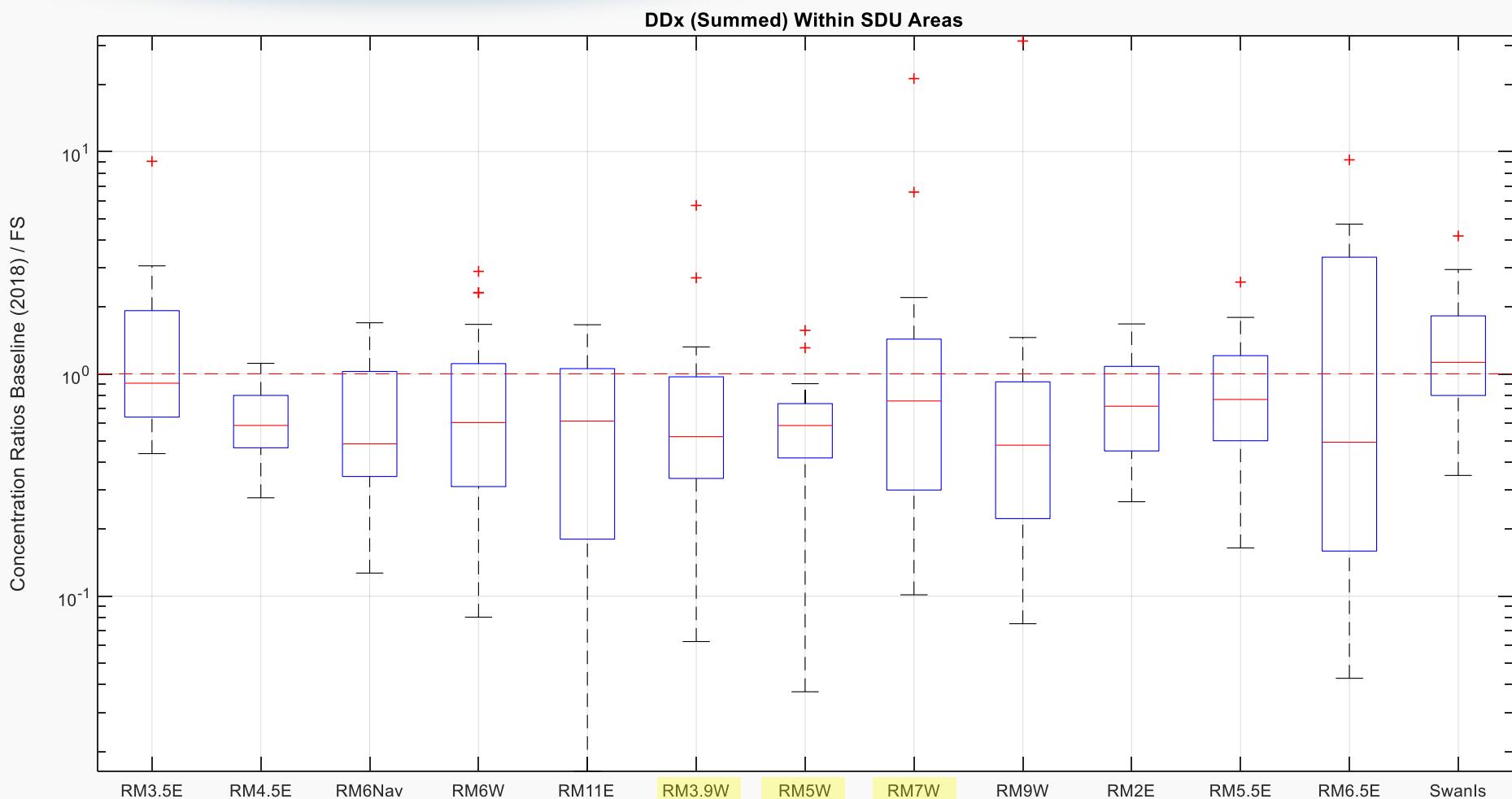
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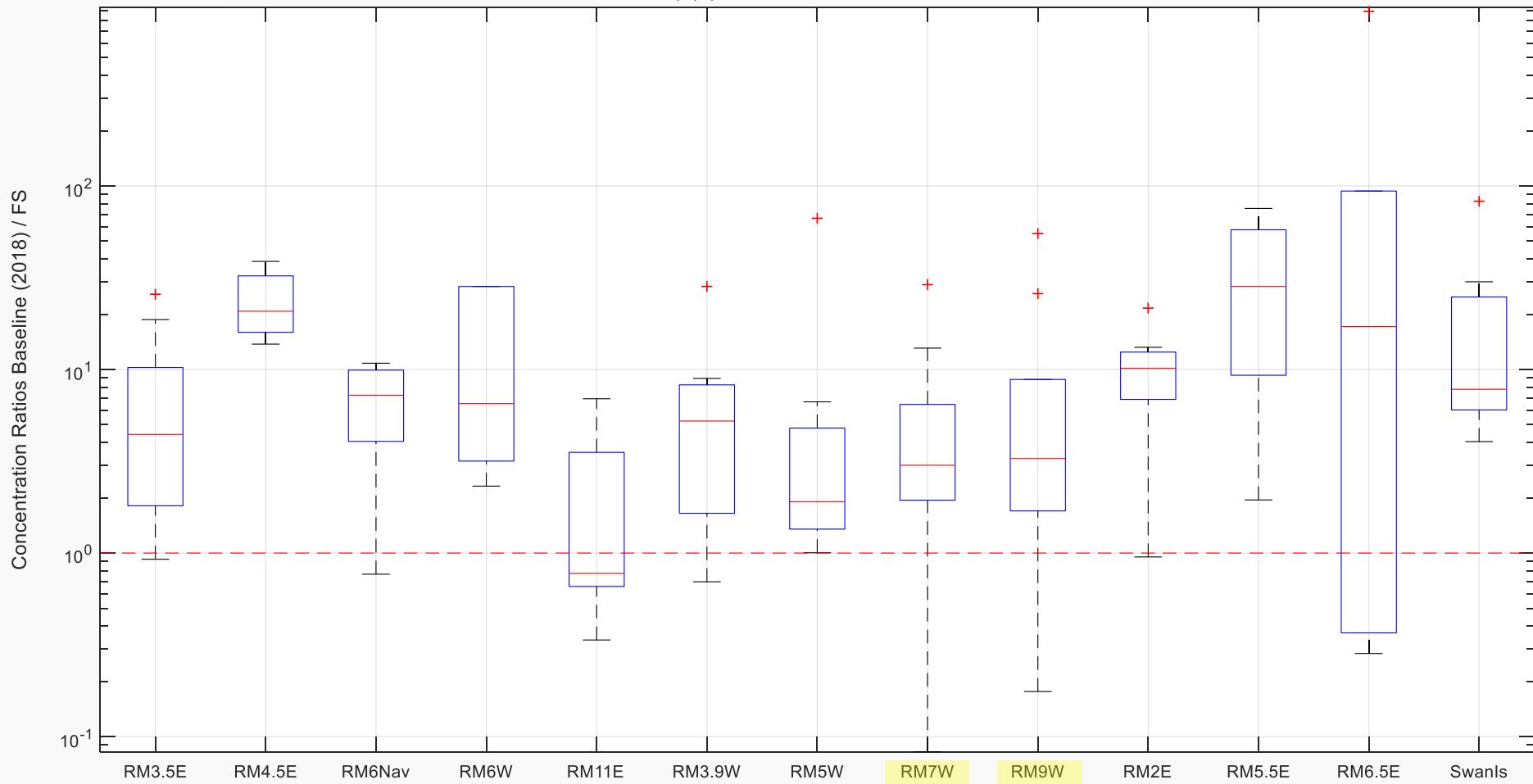
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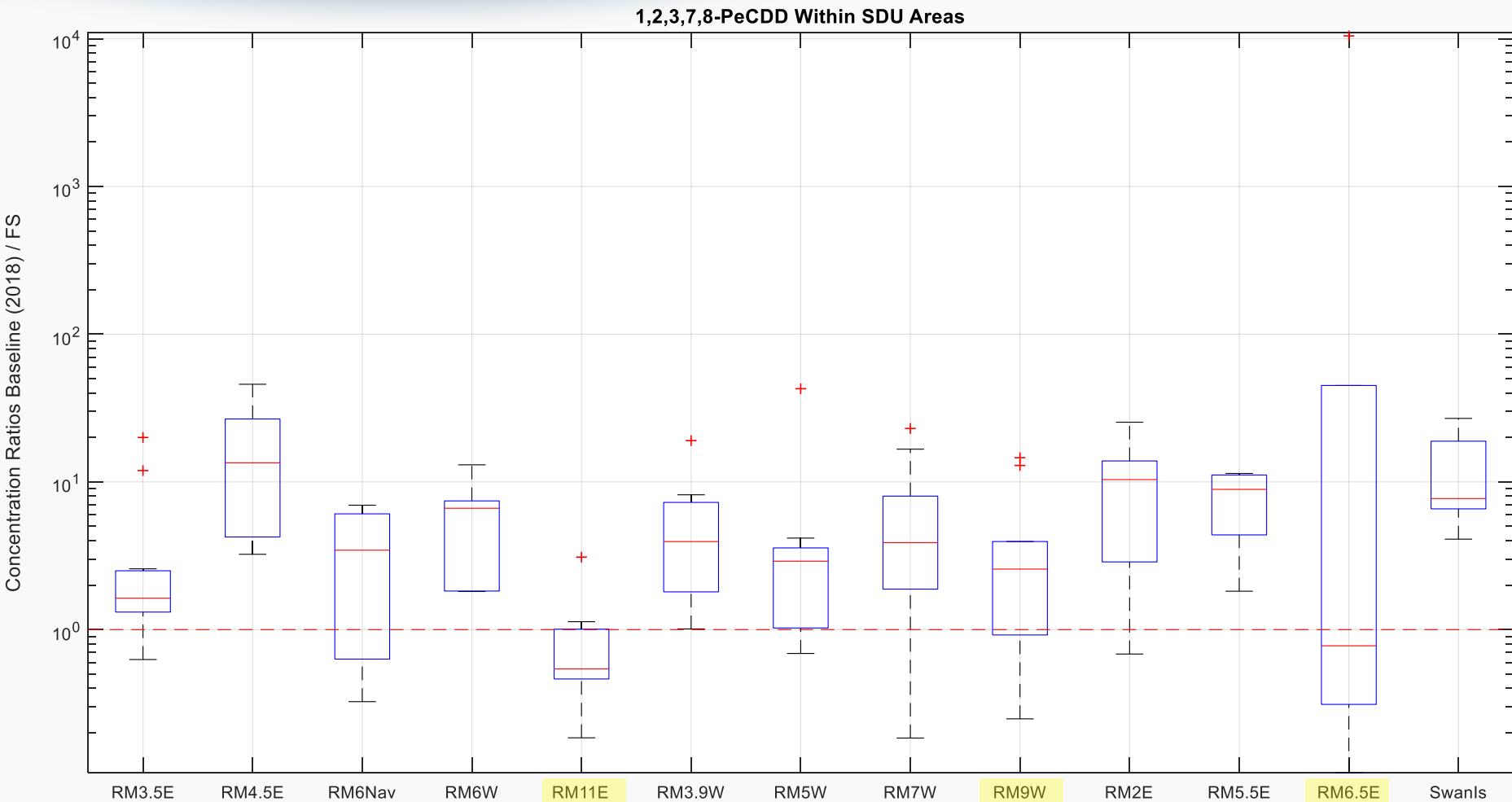
2,3,7,8-TCDD Within SDU Areas



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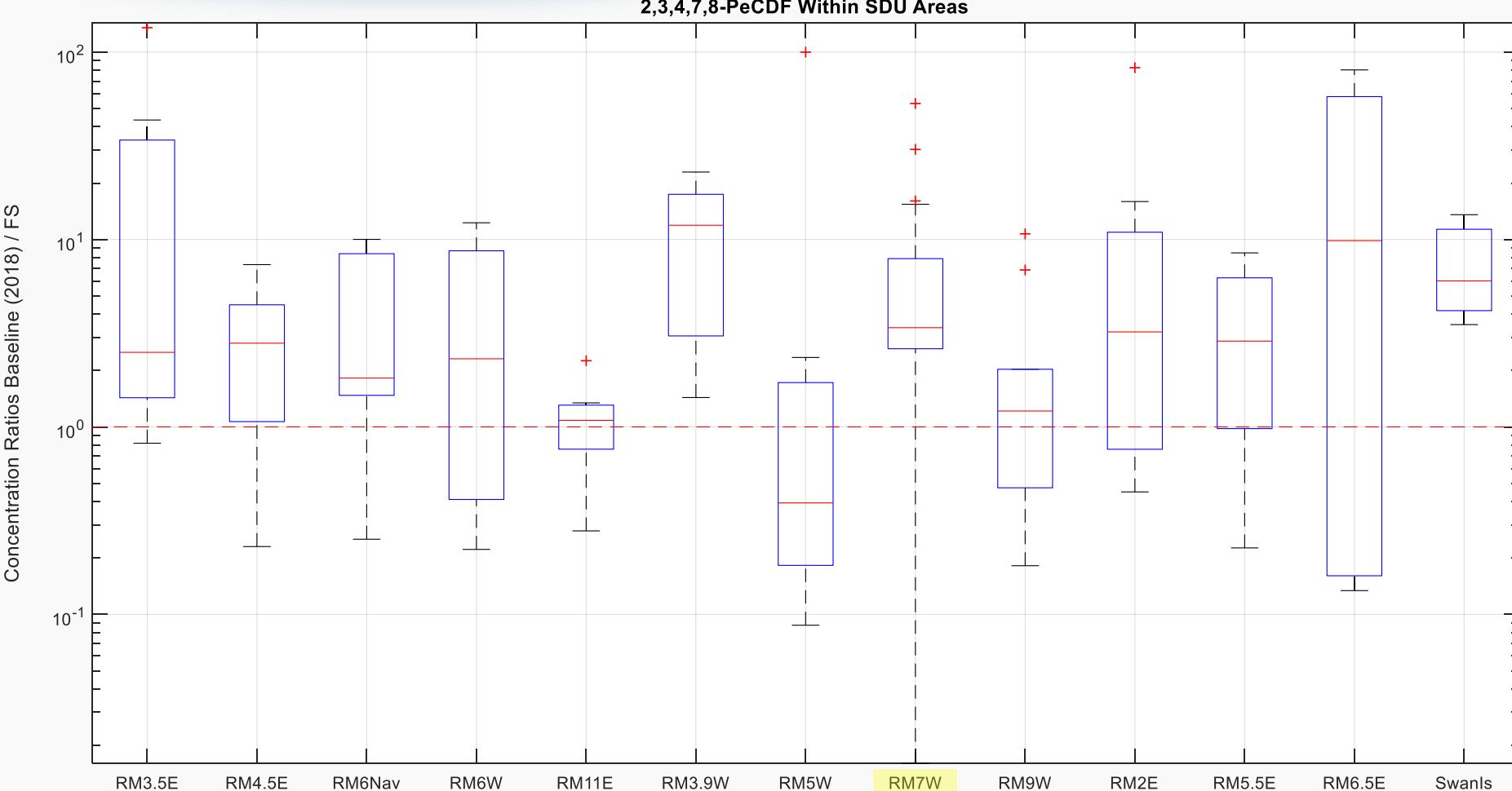
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2,3,4,7,8-PeCDF Within SDU Areas



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Significant Change in Concentrations? RI/FS to 2018

- 10 focused COCs evaluated
- **Red:** statistically significant increase
- **Green:** statistically significant decrease
- Gray: neutral (non-significant) change
- **Bold:** average concentration greater than RALs

RM 2E	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0024 ± 0.0008
1,2,3,7,8-PeCDD	0.0004 ± 0.0000
2,3,4,7,8-PeCDF	0.0008 ± 0.0002
2,3,7,8-TCDD	0.0002 ± 0.0000
2,3,7,8-TCDF	0.0012 ± 0.0002
Total DDx	04.79 ± 0.37
Naphthalene	13.32 ± 3.79
Total cPAHs	88.6 ± 15.4
Total PAHs	903.2 ± 255.7
Total PCBs	223.6 ± 113.1

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Overall SDU Change in Concentrations?

- The majority of the COCs (across SDUs) did not change significantly
- SDU color determined by overall trend of COCs
- 9 out of 13 SDUs show neutral (non-significant) change from the RI/FS to the 2018 Baseline data

Relative Concentration Change	
	Significant Decrease
	Significant Increase
	Neutral (non-significant)
	Neutral/Significant Decrease
	Neutral/Significant Increase

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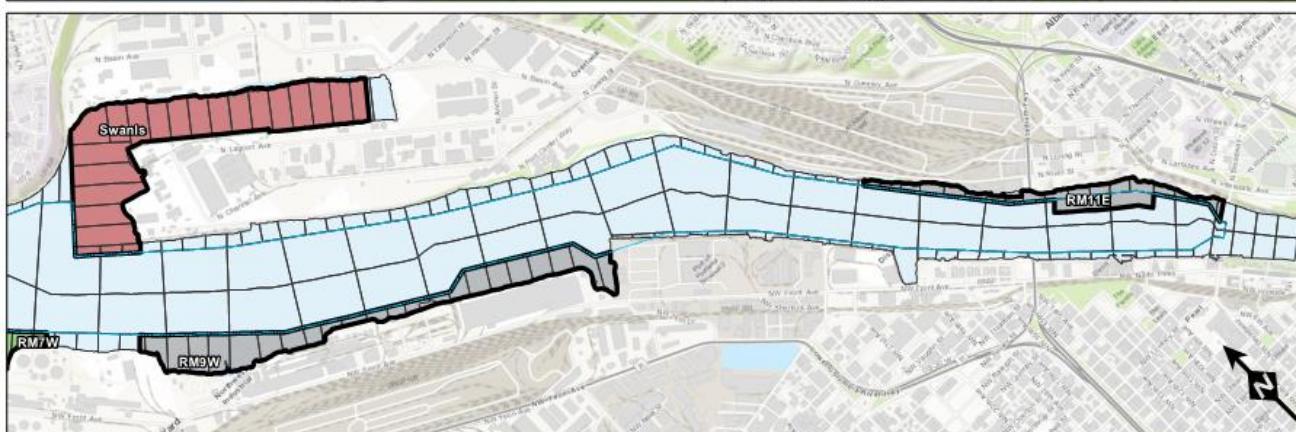
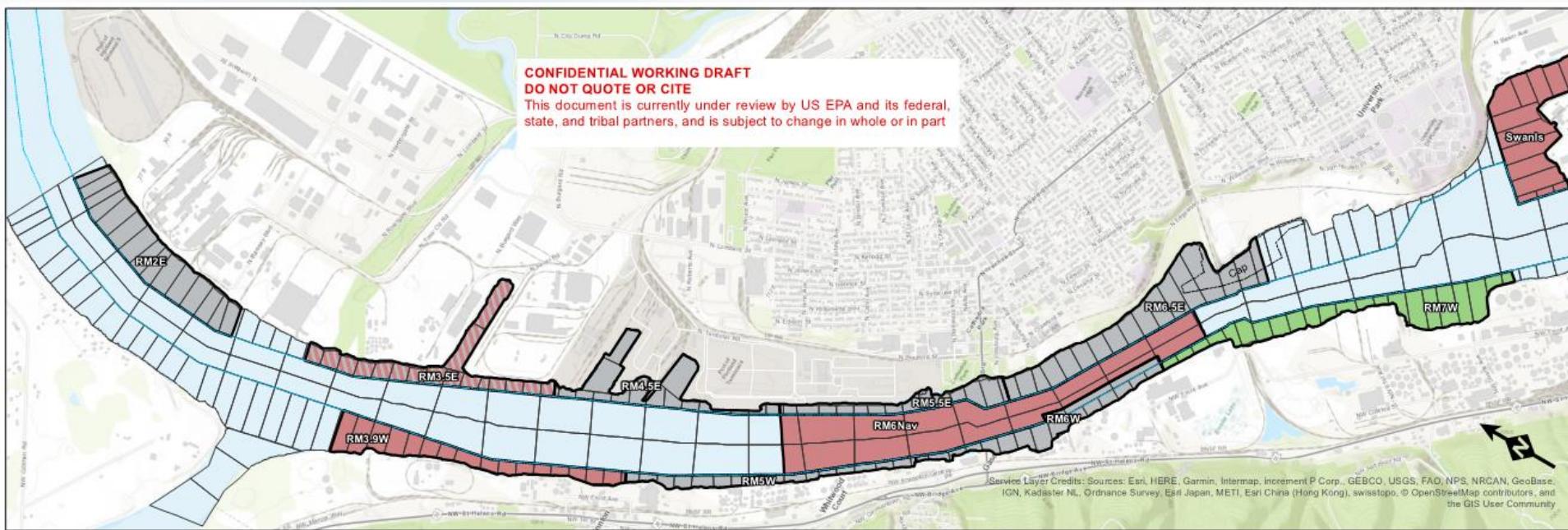
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Legend

SDU Boundary

Navigation Channel

Selection Grid

Relative Concentration Change

Significant Decrease

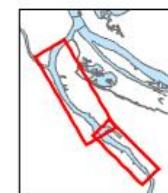
Significant Increase

Neutral (Non-Significant)

Neutral/Significant Decrease

Neutral/Significant Increase

0 1,000 2,000 3,000 4,000
Feet



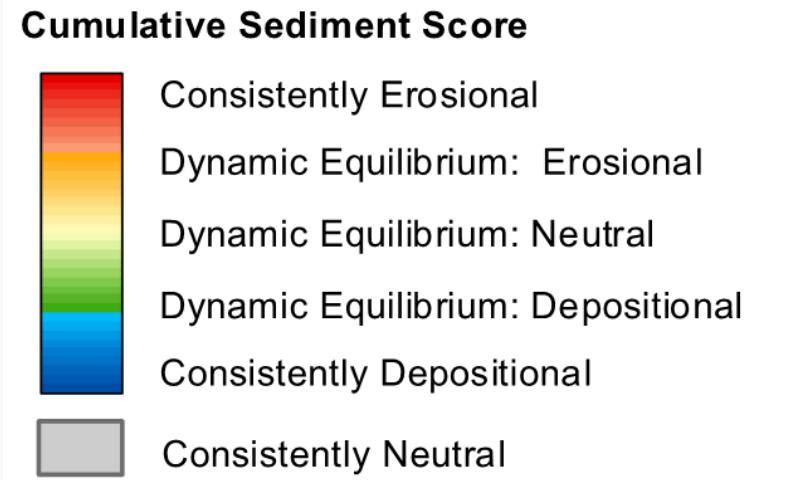
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Depositional or Erosional?

- Cumulative sediment deposition scores ranked if areas were consistently depositional, erosional, or neutral or more dynamic
- 5 bathymetry surveys included in analysis



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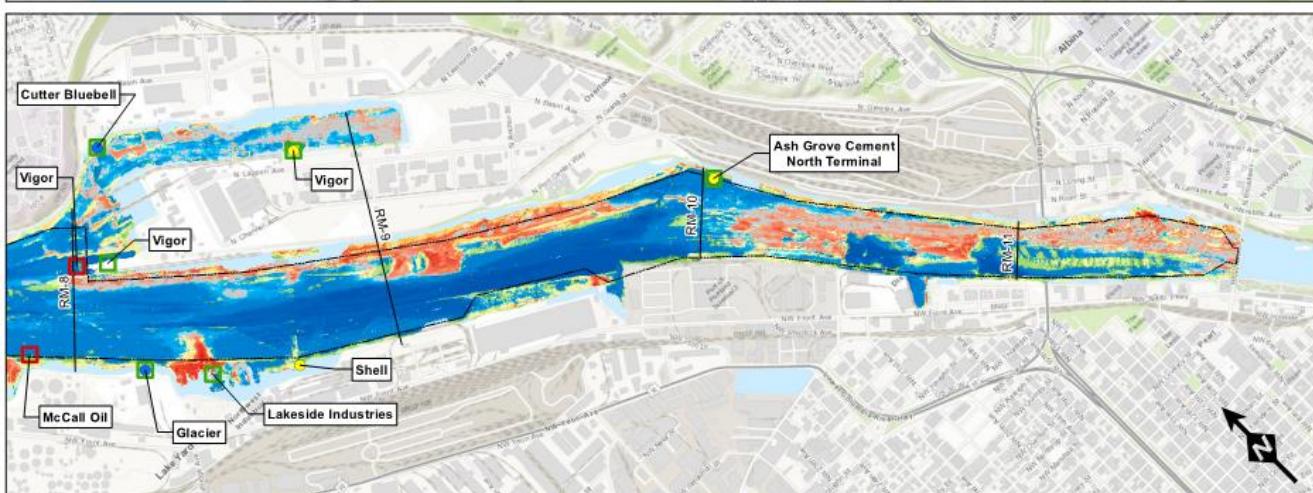
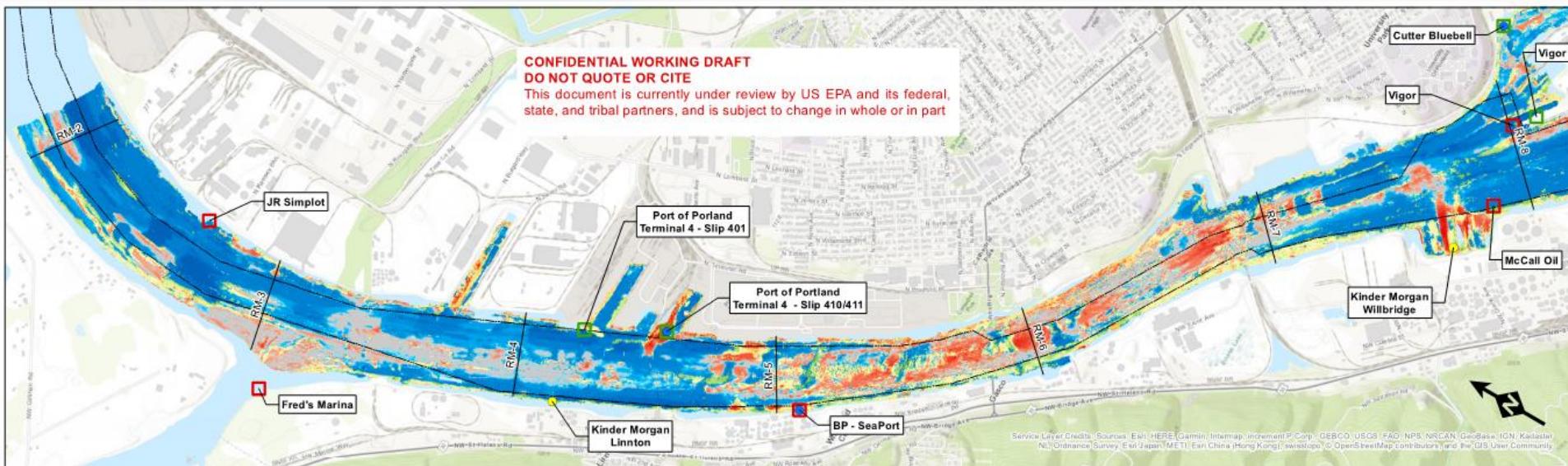
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Legend

Sand Placement Locations

- Preliminary
- Known

Proposed Dredging Locations

- Completed
- Proposed



Cumulative Sediment Score

- Consistently Erosional
- Dynamic Equilibrium: Erosional
- Dynamic Equilibrium: Neutral
- Dynamic Equilibrium: Depositional
- Consistently Depositional

Consistently Neutral



Cumulative Sediment Deposition Scores

Conclusions

- The 2018 Baseline and SMA surface sediment sampling design was not intended for “going back to FS/ROD” and developing new SMA footprints
- Areas of contamination have not changed substantially
 - Hot spot areas (e.g., Gasco, Arkema, Swan Island, RM 11E) still have high concentrations above RALs
- Areas where reduced chemical concentration at surface exist are generally co-located with increased depositional areas
 - Concentrations above RALs likely exist at depth
- Remedial Design-level data are required to refine SMA footprints (surface and subsurface) from those that are presented in the ROD

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Unbiased Statistical Evaluations

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Unbiased Statistical Evaluations

- Determine unbiased estimate of area exceeding RALs and/or PTW thresholds
- Assess uncertainty in the dataset
- Estimate relative change for focused COCs from RI/FS to 2018
- Estimate relative change on the SDU-scale

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Table 1. Mathematical notation for estimating area exceeding RAL with 95% confidence limits

Symbol	Definition	Equation
i, j	i represents the i^{th} sample within the j^{th} stratum	NA
y_{ij}	Binary indicator set to 1 when COC concentration exceeds the RAL or zero otherwise	$(y_{ij} > RAL) = \begin{cases} 1 & \text{when } y_{ij} > RAL \\ 0 & \text{otherwise} \end{cases}$
a_{ij}	Area of the i^{th} sampling grid within the j^{th} stratum.	NA
A_j	Total area of the j^{th} stratum given by summing all of the sampling grid areas	$A_j = \sum_{i=1}^{n_j} a_{ij}, \quad j=1,2,3$
\hat{P}_j	Area weighted estimate of the proportion of the j^{th} stratum exceeding the RAL	$\hat{P}_j = \frac{\sum_{i=1}^{n_j} a_{ij} \times (y_{ij} > RAL)}{A_j}$
$var(\hat{P}_j)$	Sampling variance of proportion of area exceeding the RAL within the j^{th} stratum	$var(\hat{P}_j) = \frac{\sum_{i=1}^{n_j} a_{ij}^2 \times (\hat{P}_j \times (1 - \hat{P}_j))}{A_j^2}$
$\hat{P}_{Stratified}$	Stratum Area weighted estimate of the overall proportion of area exceeding RAL	$\hat{P}_{Stratified} = \frac{A_1 \hat{P}_1 + A_2 \hat{P}_2 + A_3 \hat{P}_3}{A_1 + A_2 + A_3}$
$\hat{A}_{Stratified}$	Area exceeding RAL (Acres)	$\hat{A}_{Stratified} = \hat{P}_{Stratified} \times \sum_{j=1}^3 A_j$
$var(\hat{P}_{Stratified})$	Sampling variance of the proportion of area exceeding RAL	$var(\hat{P}_{Stratified}) = \frac{A_1^2 \times var(\hat{P}_1) + A_2^2 \times var(\hat{P}_2) + A_3^2 \times var(\hat{P}_3)}{(A_1 + A_2 + A_3)^2}$
$SE(\hat{P}_{Stratified})$	Standard error of proportion of area exceeding RAL	$SE(\hat{P}_{Stratified}) = \sqrt{var(\hat{P}_{Stratified})}$
$SE(\hat{A}_{Stratified})$	Standard error of area exceeding RAL	$SE(\hat{A}_{Stratified}) = A \times SE(\hat{P}_{Stratified})$
LCL 95	Lower limit area exceeding RAL	$\hat{A}_{Stratified} - 1.96 \times SE(\hat{A}_{Stratified}) =$
UCL 95	Upper limit area exceeding RAL	$\hat{A}_{Stratified} + 1.96 \times SE(\hat{A}_{Stratified}) =$

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Unbiased Estimate of Area Exceeding RALs

2018 SMAs: 279.9 acres

95% Confidence Interval: 185.5 to 374.3 acres

Interpolation Method for Area Exceeding RALs

ROD SMAs: 365 acres

2018 SMAs: 422 acres

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What is the uncertainty in the 2018 dataset?

- Wide confidence intervals
- Spatial density not sufficient for fully redefining SMAs
- Provides unbiased estimate of area exceeding RALs

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Active Remediation Areas by COC

COC	95% LCL (acres)	95% UCL (acres)
1,2,3,4,7,8-HxCDF	0	0
1,2,3,7,8-PeCDD	98.1	251.2
2,3,4,7,8-PeCDF	0	29.5
2,3,7,8-TCDD	41.8	160.4
2,3,7,8-TCDF	0	0
Total DDx	0	49.7
Naphthalene	0	0
Total PAHs	9.4	96.1
Total PCBs	113.1	273.5
Total cPAHs	0	0

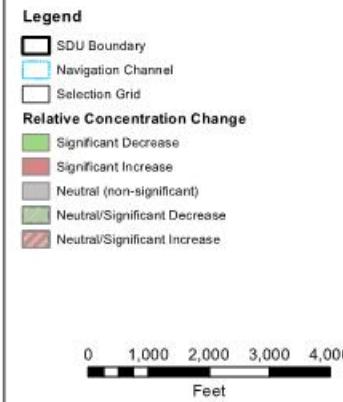
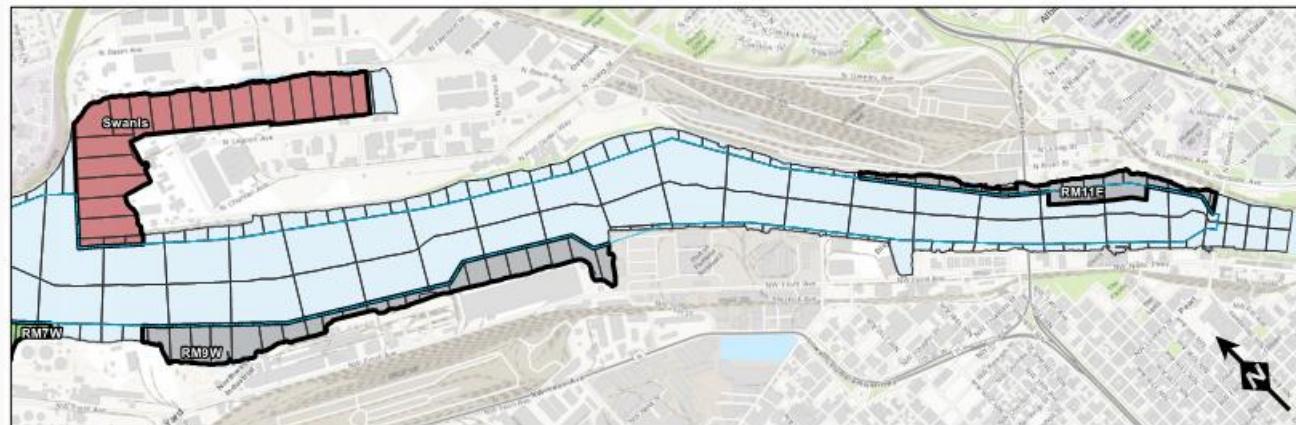
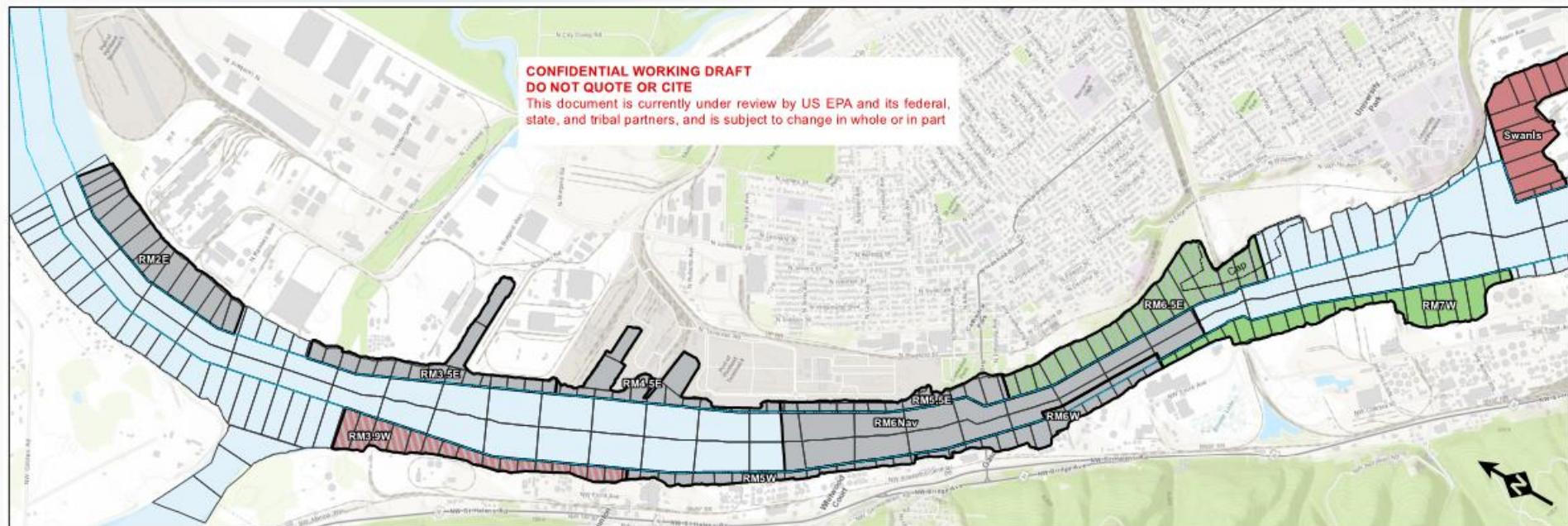
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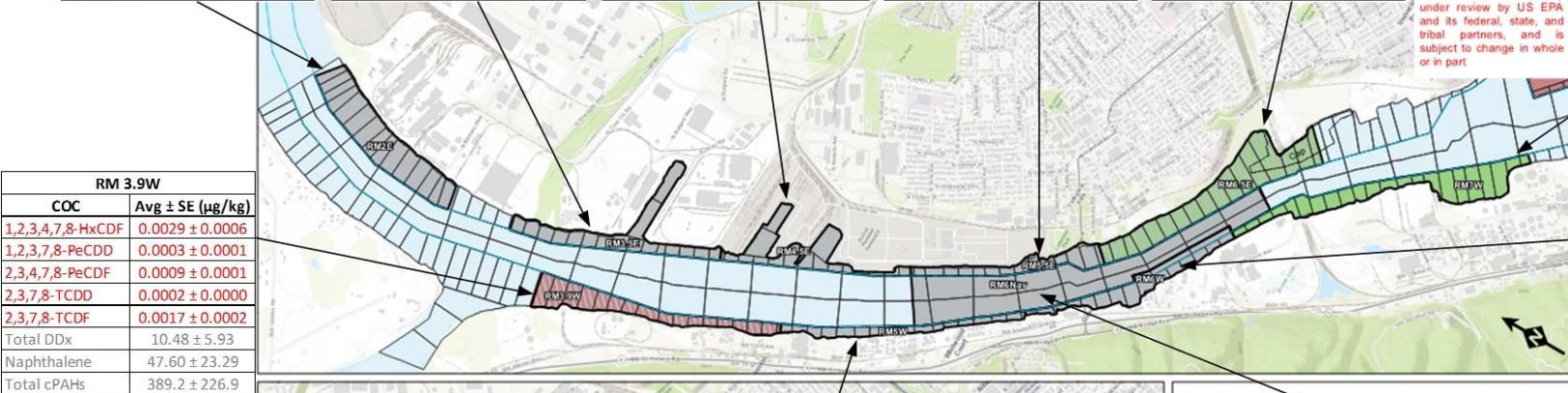


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RM 2E		RM 3.5E		RM 4.5E		RM 5.5E		RM 6.5E	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)	COC	Avg ± SE ($\mu\text{g}/\text{kg}$)	COC	Avg ± SE ($\mu\text{g}/\text{kg}$)	COC	Avg ± SE ($\mu\text{g}/\text{kg}$)	COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0013 ± 0.0002	1,2,3,4,7,8-HxCDF	0.0020 ± 0.0007	1,2,3,4,7,8-HxCDF	0.0198 ± 0.0123	1,2,3,4,7,8-HxCDF	0.0043 ± 0.0014	1,2,3,4,7,8-HxCDF	0.0010 ± 0.0005
1,2,3,7,8-PeCDD	0.0004 ± 0.0000	1,2,3,7,8-PeCDD	0.0003 ± 0.0001	1,2,3,7,8-PeCDD	0.0006 ± 0.0003	1,2,3,7,8-PeCDD	0.0028 ± 0.0012	1,2,3,7,8-PeCDD	0.0014 ± 0.0011
2,3,4,7,8-PeCDF	0.0004 ± 0.0000	2,3,4,7,8-PeCDF	0.0006 ± 0.0003	2,3,4,7,8-PeCDF	0.0055 ± 0.0034	2,3,4,7,8-PeCDF	0.0012 ± 0.0004	2,3,4,7,8-PeCDF	0.0004 ± 0.0001
2,3,7,8-TCDD	0.0002 ± 0.0000	2,3,7,8-TCDD	0.0001 ± 0.0000	2,3,7,8-TCDD	0.0002 ± 0.0000	2,3,7,8-TCDD	0.0003 ± 0.0002	2,3,7,8-TCDD	0.0002 ± 0.0001
2,3,7,8-TCDF	0.0008 ± 0.0001	2,3,7,8-TCDF	0.0010 ± 0.0003	2,3,7,8-TCDF	0.0013 ± 0.0004	2,3,7,8-TCDF	0.0017 ± 0.0005	2,3,7,8-TCDF	0.0007 ± 0.0002
Total DDX	04.68 ± 0.38	Total DDX	06.19 ± 1.03	Total DDX	07.49 ± 0.92	Total DDX	06.60 ± 1.88	Total DDX	02.64 ± 0.71
Naphthalene	16.01 ± 8.56	Naphthalene	07.17 ± 1.03	Naphthalene	306.45 ± 123.89	Naphthalene	144.91 ± 76.74	Naphthalene	13.75 ± 5.90
Total cPAHs	62.2 ± 7.9	Total cPAHs	85.0 ± 10.2	Total cPAHs	1833.4 ± 696.3	Total cPAHs	602.7 ± 226.0	Total cPAHs	88.7 ± 51.5
Total PAHs	536.8 ± 95.4	Total PAHs	686.8 ± 88.5	Total PAHs	15370.8 ± 5921.7	Total PAHs	5129.7 ± 1609.9	Total PAHs	1072.6 ± 514.7
Total PCBs	21.7 ± 4.2	Total PCBs	44.3 ± 9.8	Total PCBs	19.9 ± 3.8	Total PCBs	142.6 ± 57.7	Total PCBs	32.7 ± 21.7



RM 3.9W	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0029 ± 0.0006
1,2,3,7,8-PeCDD	0.0003 ± 0.0001
2,3,4,7,8-PeCDF	0.0009 ± 0.0001
2,3,7,8-TCDD	0.0002 ± 0.0000
2,3,7,8-TCDF	0.0017 ± 0.0002
Total DDX	10.48 ± 5.93
Naphthalene	47.60 ± 23.29
Total cPAHs	389.2 ± 226.9
Total PAHs	3731.9 ± 2685.8
Total PCBs	36.0 ± 18.0

Swan Island Lagoon	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0100 ± 0.0036
1,2,3,7,8-PeCDD	0.0017 ± 0.0002
2,3,4,7,8-PeCDF	0.0018 ± 0.0003
2,3,7,8-TCDD	0.0009 ± 0.0002
2,3,7,8-TCDF	0.0026 ± 0.0005
Total DDX	08.81 ± 0.78
Naphthalene	32.08 ± 6.15
Total cPAHs	251.1 ± 31.3
Total PAHs	2400.1 ± 326.1
Total PCBs	399.4 ± 119.2

RM 9W	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0018 ± 0.0004
1,2,3,7,8-PeCDD	0.0006 ± 0.0001
2,3,4,7,8-PeCDF	0.0005 ± 0.0001
2,3,7,8-TCDD	0.0004 ± 0.0001
2,3,7,8-TCDF	0.0007 ± 0.0001
Total DDX	06.61 ± 1.44
Naphthalene	12.89 ± 3.45
Total cPAHs	75.6 ± 14.2
Total PAHs	903.2 ± 157.5
Total PCBs	45.4 ± 7.5

RM 5W	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0036 ± 0.0007
1,2,3,7,8-PeCDD	0.0003 ± 0.0001
2,3,4,7,8-PeCDF	0.0008 ± 0.0002
2,3,7,8-TCDD	0.0003 ± 0.0001
2,3,7,8-TCDF	0.0018 ± 0.0005
Total DDX	07.20 ± 1.07
Naphthalene	31.22 ± 14.12
Total cPAHs	284.0 ± 67.7
Total PAHs	2219.9 ± 587.6
Total PCBs	19.6 ± 2.8

RM 11E	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0009 ± 0.0005
1,2,3,7,8-PeCDD	0.0003 ± 0.0001
2,3,4,7,8-PeCDF	0.0003 ± 0.0001
2,3,7,8-TCDD	0.0002 ± 0.0001
2,3,7,8-TCDF	0.0006 ± 0.0002
Total DDX	02.58 ± 0.70
Naphthalene	10.20 ± 10.68
Total cPAHs	45.3 ± 31.2
Total PAHs	380.4 ± 263.6
Total PCBs	348.4 ± 275.3

RM 7W	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.8332 ± 0.7776
1,2,3,7,8-PeCDD	0.0007 ± 0.0002
2,3,4,7,8-PeCDF	0.1964 ± 0.1605
2,3,7,8-TCDD	0.0003 ± 0.0001
2,3,7,8-TCDF	0.4536 ± 0.4675
Total DDX	1279.1 ± 1381.4
Naphthalene	13.17 ± 5.92
Total cPAHs	254.6 ± 151.8
Total PAHs	2837.1 ± 1708.8
Total PCBs	52.8 ± 16.9

RM 6W	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0481 ± 0.0257
1,2,3,7,8-PeCDD	0.0008 ± 0.0002
2,3,4,7,8-PeCDF	0.0114 ± 0.0055
2,3,7,8-TCDD	0.00055 ± 0.0001
2,3,7,8-TCDF	0.0206 ± 0.0077
Total DDX	74.08 ± 28.45
Naphthalene	779.67 ± 315.41
Total cPAHs	8480.1 ± 4453.2
Total PAHs	94349 ± 57958
Total PCBs	45.0 ± 16.2

RM 6Nav	
COC	Avg ± SE ($\mu\text{g}/\text{kg}$)
1,2,3,4,7,8-HxCDF	0.0098 ± 0.0089
1,2,3,7,8-PeCDD	0.0004 ± 0.0003
2,3,4,7,8-PeCDF	0.0019 ± 0.0015
2,3,7,8-TCDD	0.0002 ± 0.0001
2,3,7,8-TCDF	0.0041 ± 0.0031
Total DDX	11.32 ± 5.48
Naphthalene	559.70 ± 194.10
Total cPAHs	8795.3 ± 4848.3
Total PAHs	122932 ± 68737
Total PCBs	30.0 ± 15.3

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Feet

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2018 Baseline Sampling



Contribution of Dioxins/Furans to Surface Sediment-Based SMAs

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2018 Baseline Sampling



New Site-Wide Dioxins/Furans Data

Dioxin/Furan Surface Sediment Samples

- RI/FS: 222 samples
- 2018: 661 samples
- First set of Site-wide dioxin/furan surface sediment data
- 2018 data discovers new areas with dioxin/furan RAL exceedances



PDI Remediation Area (~422 acres)



Dioxin/Furan RALs and PTW (~60 acres)



Dioxin/Furans Covered by Other COCs and PTW (~198 acres)

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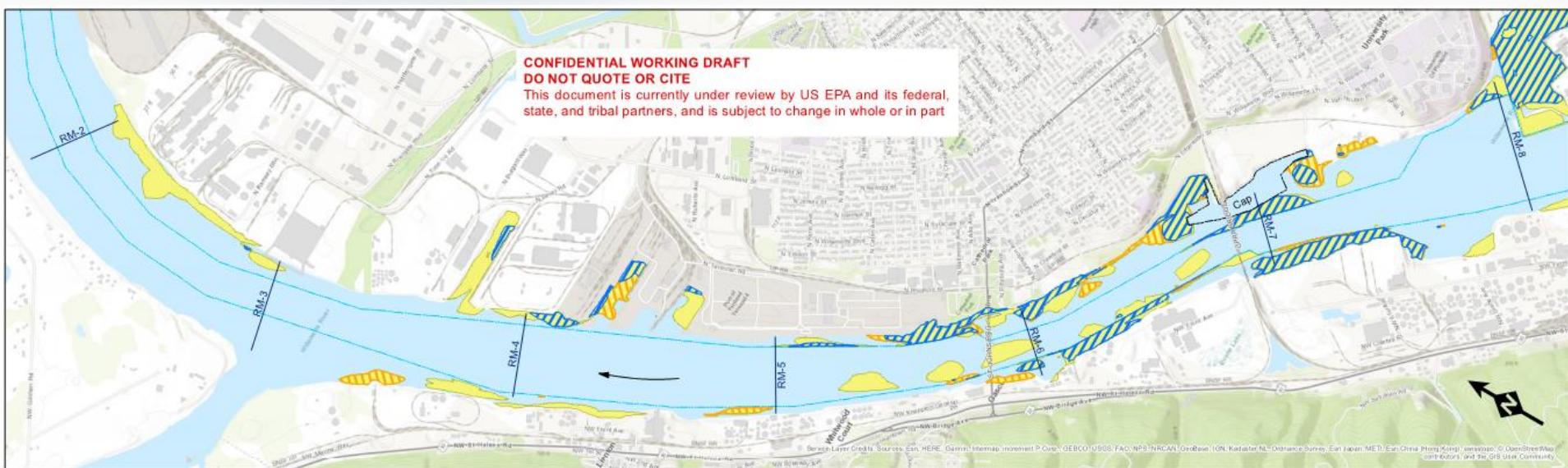
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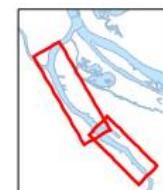
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part



Legend

- ← River Flow
- Navigation Channel
- PDI Remediation Area (~422 acres)
- Dioxin/Furan RALs and PTW (~60 acres)
- Dioxin/Furans Covered by Other COCs and PTW (~198 acres)

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What does this mean?

- Remedial Design investigations may discover new areas with dioxin/furan contamination
- May contribute to and/or increase the size of SMA footprints
- Needs to be fully investigated during Remedial Design sampling

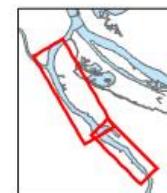
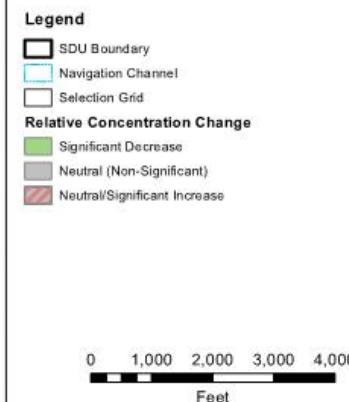
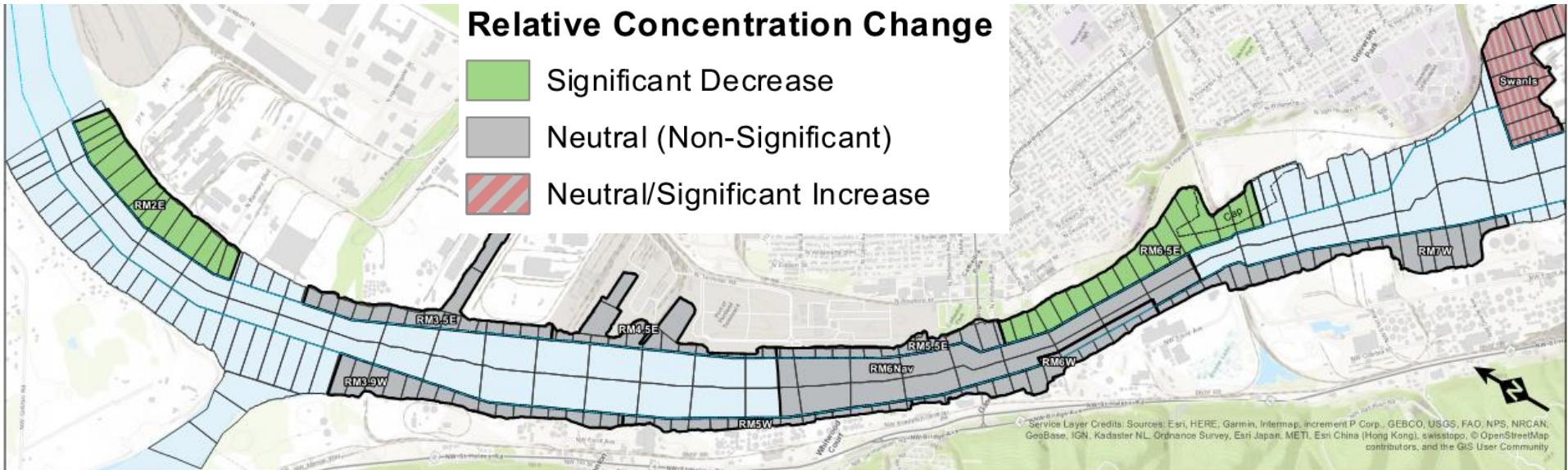
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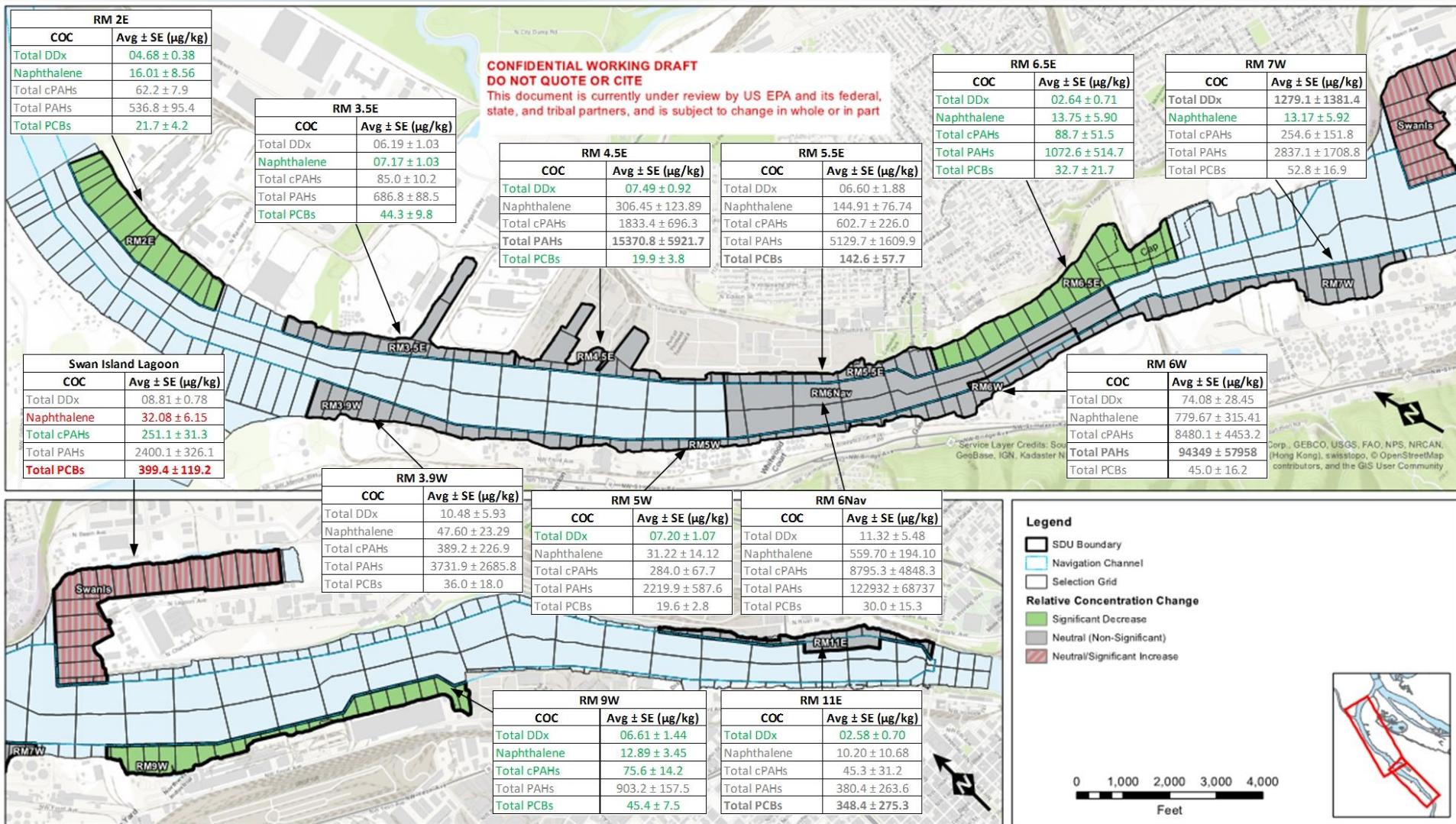


How did the concentrations change statistically without D/F?



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2018 Baseline Sampling



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Additional Analyses

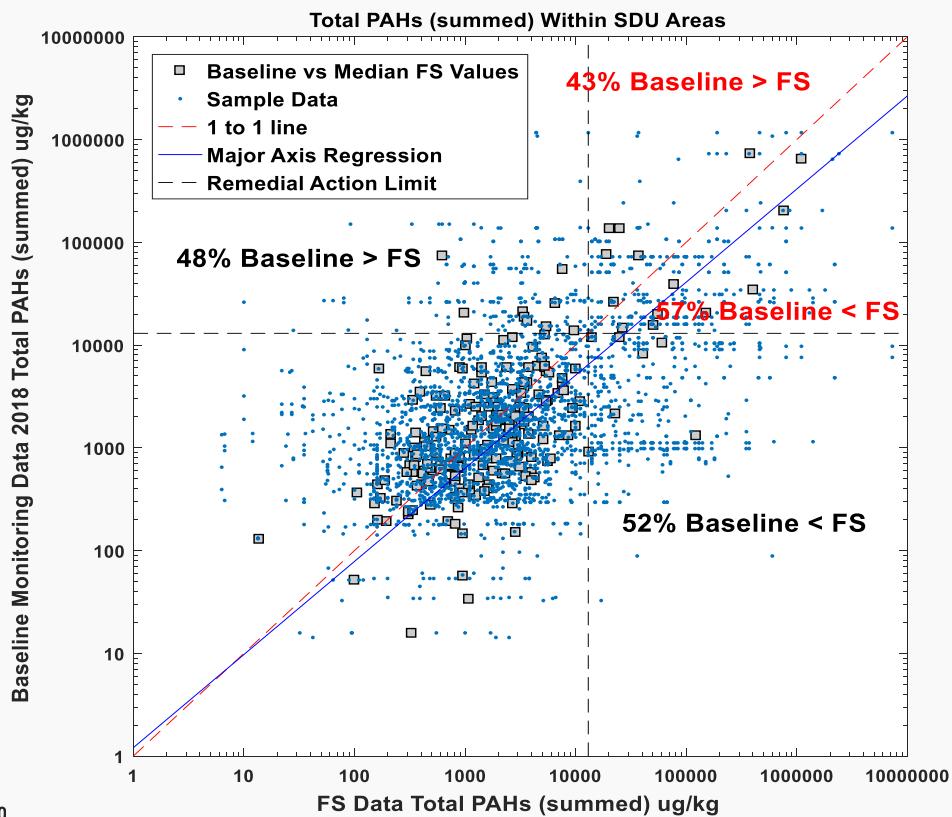
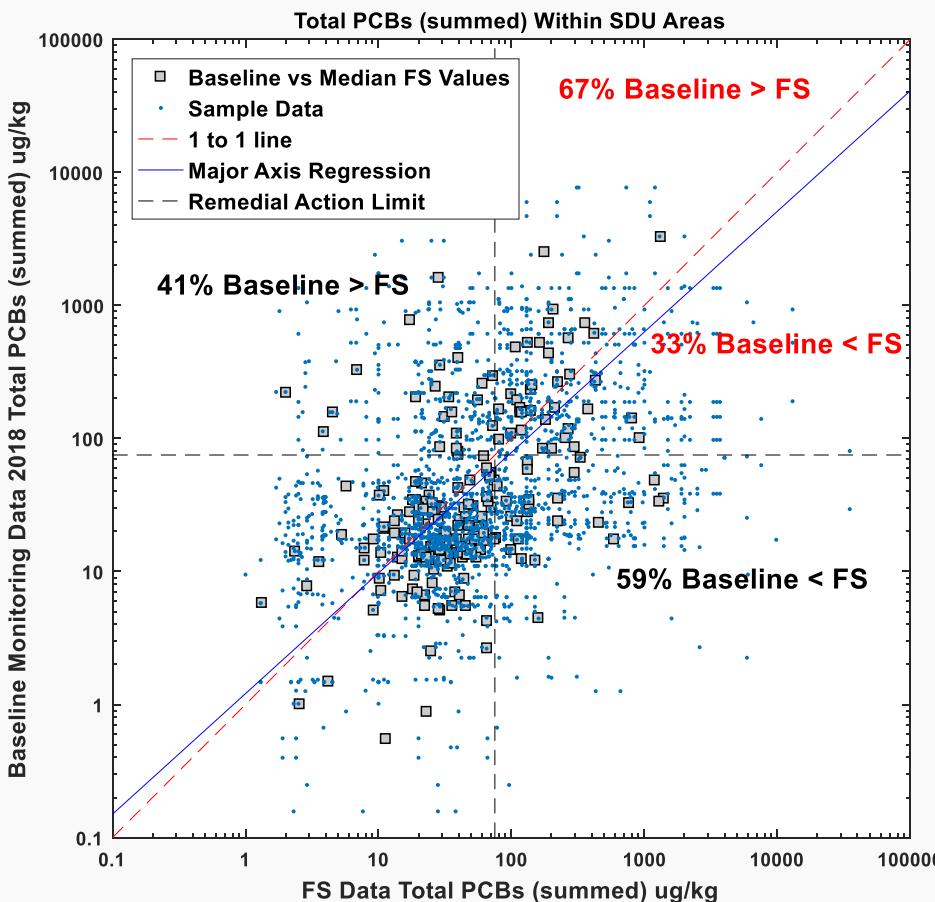
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2018 Baseline Sampling



Concentration Change Regression Analysis



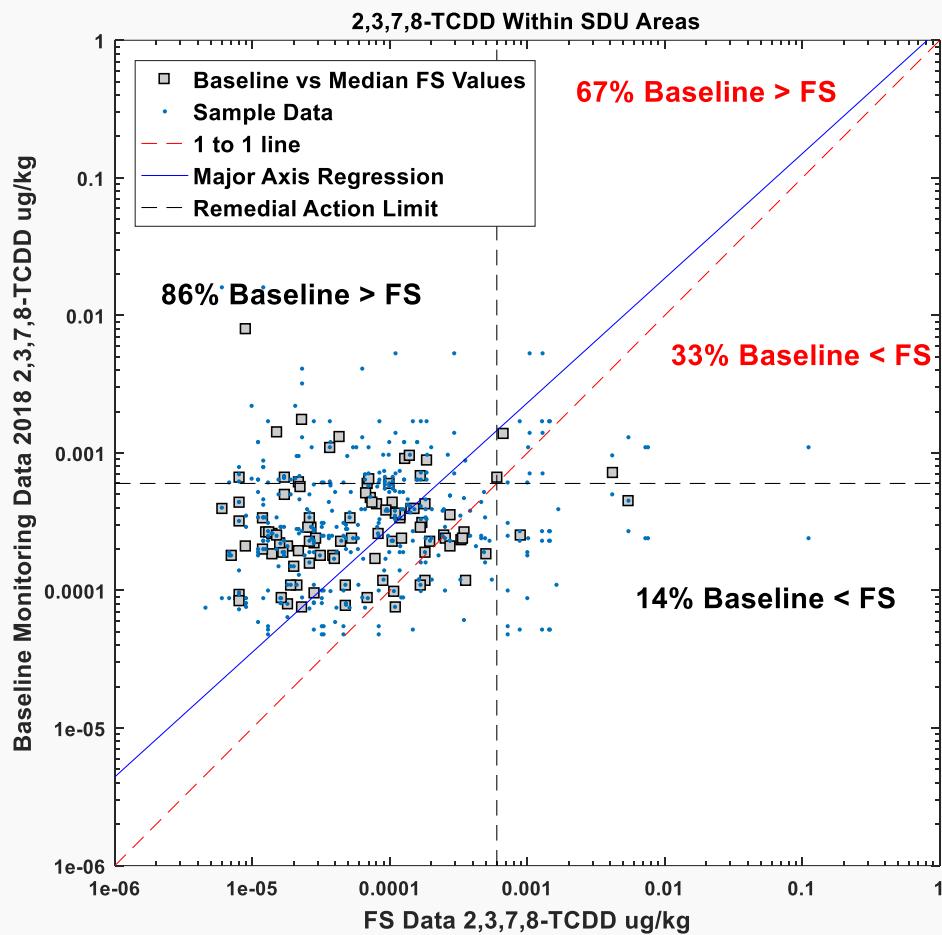
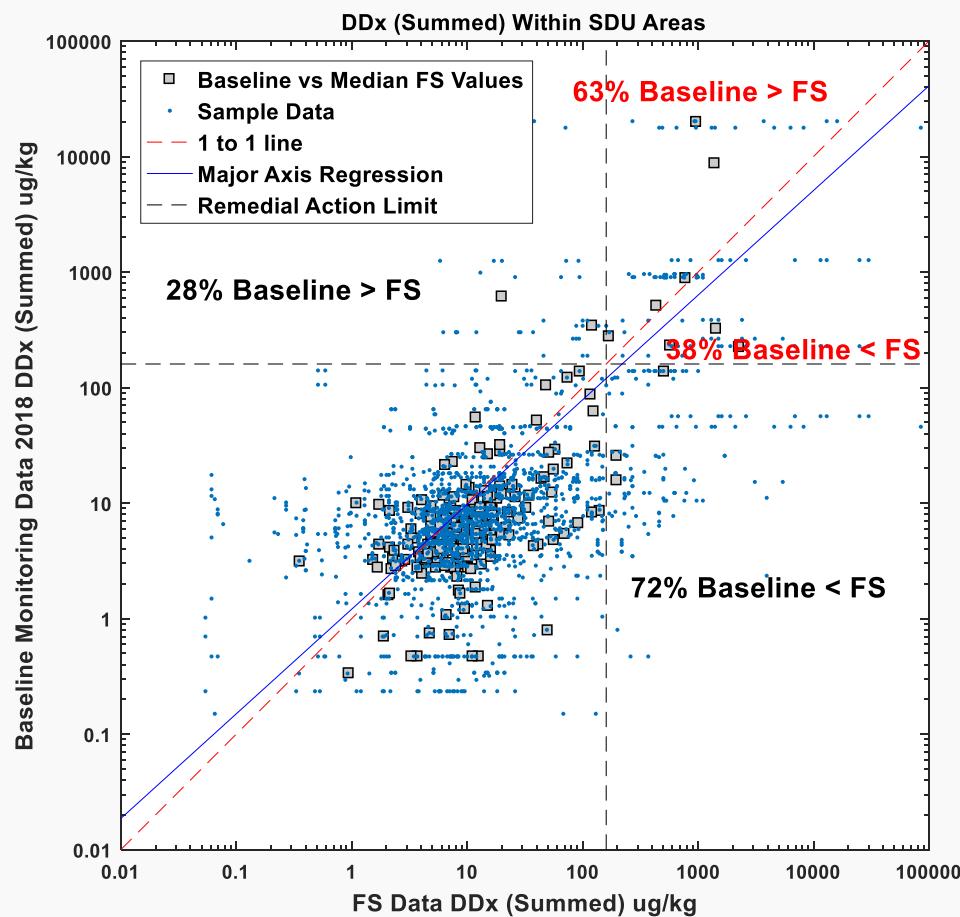
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2018 Baseline Sampling



Concentration Change Regression Analysis



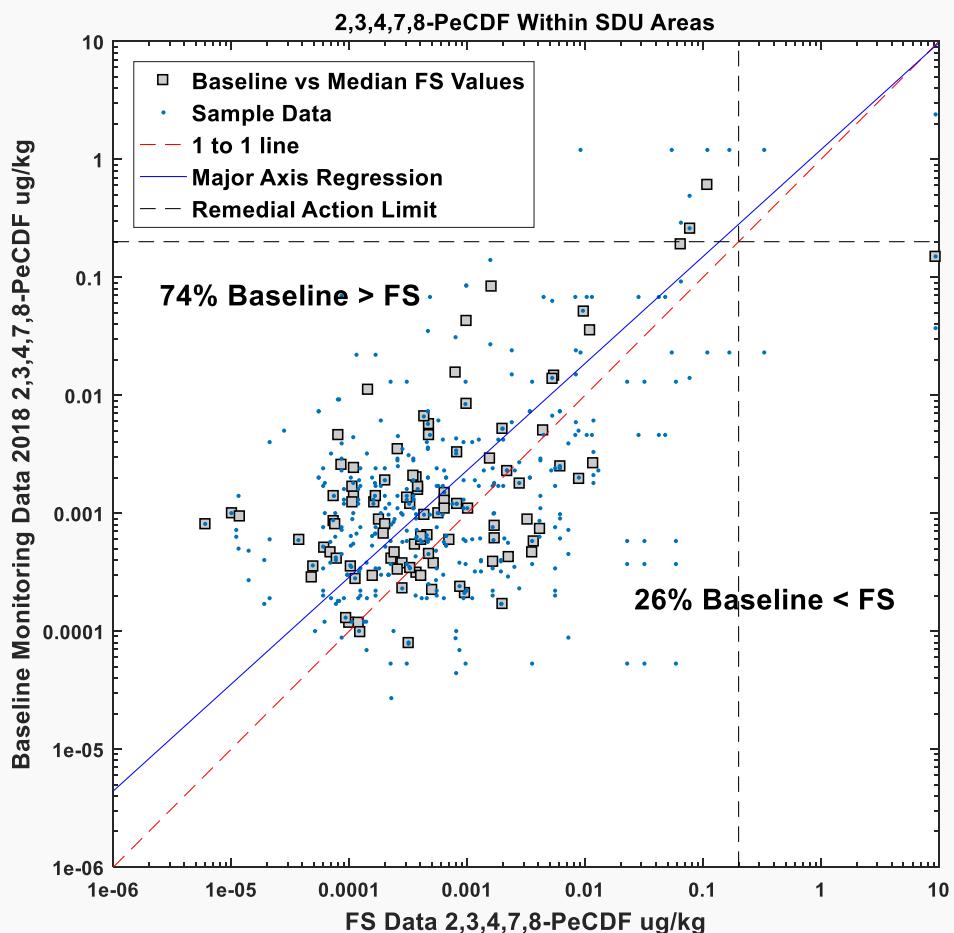
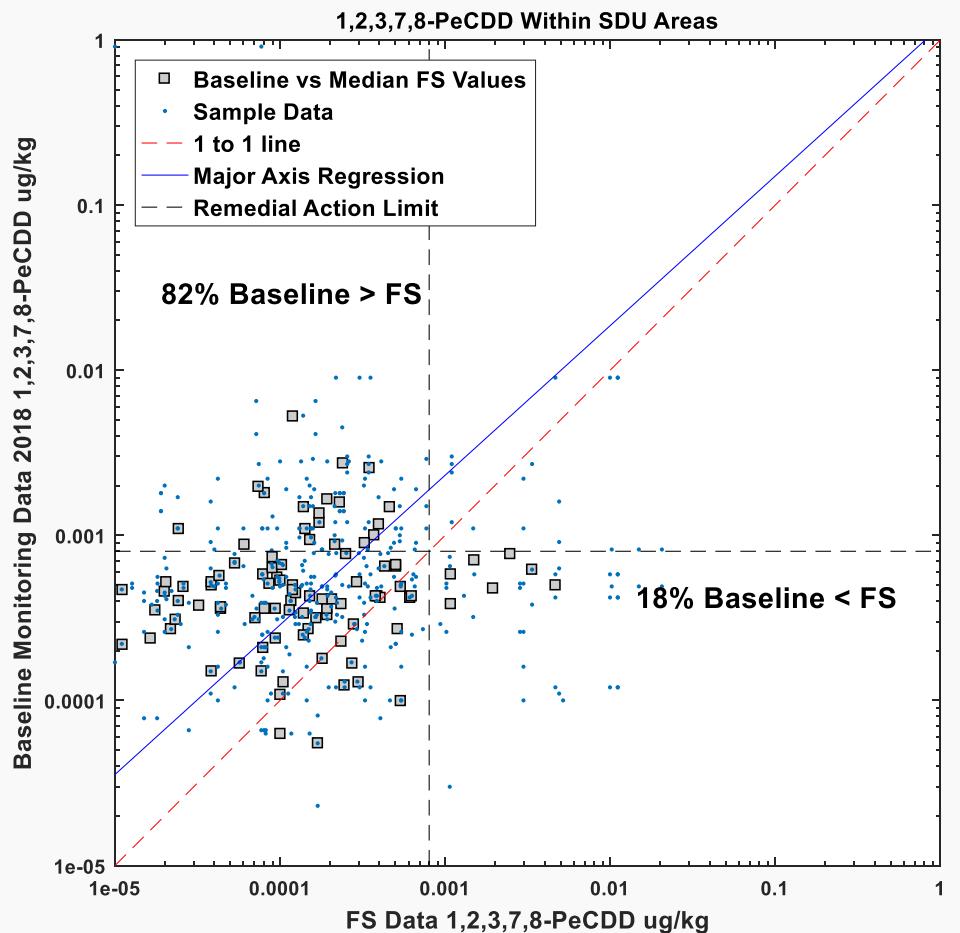
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Concentration Change Regression Analysis



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2018 Baseline Surface Sediment Map – Total PCBs

Total PCBs (ug/kg)

- ≤ 9
- >9 - 50
- >50 - 75
- >75 - 200
- >200 - 500
- >500 - 750
- >750 - 1,000
- >1,000

- White: <CUL
- Blue and Dark Green: >CUL but <RAL
- Light Green: >nearshore RAL but <PTW threshold
- Yellow, Orange, and Red: >PTW threshold but <Nav Channel RAL
- Dark Red: >Nav Channel RAL

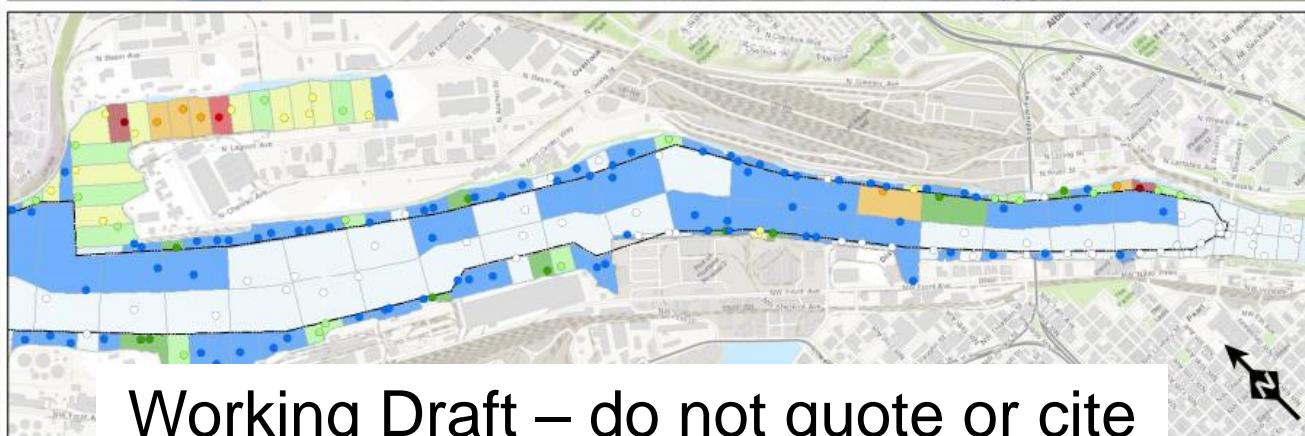
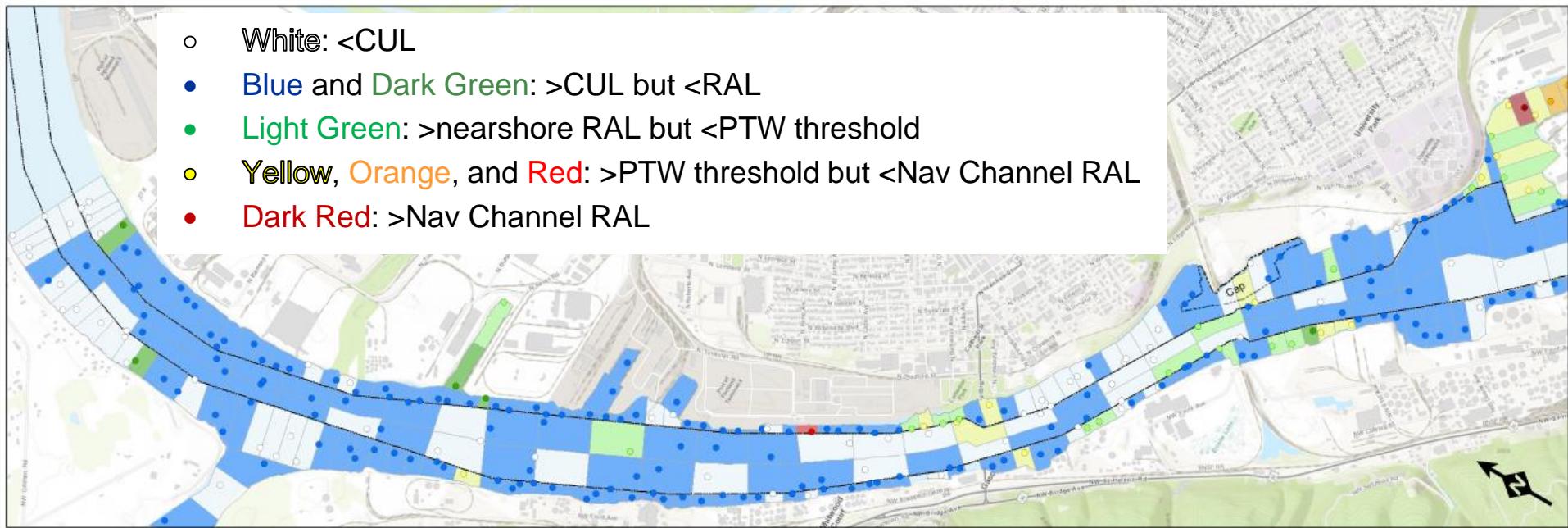
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2018 Baseline Sampling



- White: < CUL
- Blue and Dark Green: > CUL but < RAL
- Light Green: > nearshore RAL but < PTW threshold
- Yellow, Orange, and Red: > PTW threshold but < Nav Channel RAL
- Dark Red: > Nav Channel RAL



Legend	
Navigation Channel	
Total PCBs (ug/kg)	
○	≤ 9
●	>9 - 50
●	>50 - 75
●	>75 - 200
●	>200 - 500
●	>500 - 750
●	>750 - 1,000
●	>1,000

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Feet

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